

Alkalinity Fact Sheet

See related information: Acronyms & Abbreviations; Glossary of Terms and Treatment Technology Fact Sheet.

Contaminant Data

Chemical Data Alkalinity is the quantitative capacity of water to neutralize an acid. In practice, alkalinity is determined as the amount of strong acid needed to titrate a water sample to a pH of 4.7 [1]. Alkalinity is the sum of the strong bases minus the sum of strong acids in water, therefore, alkalinity can be either positive or negative. If the concentration of strong acids exceeds the concentration of strong bases, alkalinity is negative [2]. Water does not have to be strongly basic (high pH) to have high alkalinity. Total alkalinity, typically expressed as CaCO_3 equivalent, is the sum of HCO_3^- , CO_3^{2-} , HPO_4^{2-} , PO_4^{3-} , H_3SiO_4^- , H_2BO_2^- , CH_3COO^- , OH^- minus H^+ . The constituents of alkalinity commonly found in drinking water applications are: HCO_3^- , CO_3^{2-} , and OH^- . Bicarbonate (HCO_3^-) in surface waters at neutral pH is typically >95% of the total alkalinity. There are three different tests used for measuring alkalinity, usually performed in this order: pH (to obtain OH^- alkalinity), phenolphthalein test (to obtain OH^- and CO_3^{2-} alkalinity), and methyl orange test (to obtain total alkalinity). In most waters, alkalinity and hardness (the concentration of divalent ions) have similar values because HCO_3^- and CO_3^{2-} are usually derived from CaCO_3 or MgCO_3 .

Source in Nature In the environment, alkalinity in the soil (limestone) and ground and surface waters is a combination of the naturally occurring alkalis: CO_3^{2-} , HCO_3^- , and OH^- salts of Ca, Mg, K, and Na. Most natural waters have an alkalinity in the range of 10 to 500 mg/L. Wastewater is normally alkaline, receiving alkalinity from the water supply, ground water, and materials added during domestic use including detergents and soap-based products which are alkaline. Acid rain also contributes to the alkalinity of waters.

SDWA Limits Alkalinity is not a primary or a secondary drinking water contaminant. No federal limits exist.

Health Effects Alkalis, when dissolved in water, create a bitter taste and a slippery feel. Highly alkaline waters, above pH 7.0, can cause drying of the skin. Alkalinity is important for fish and aquatic life because it protects or buffers against rapid pH changes and makes water less vulnerable to acid rain, protecting a major source of human consumption.

Removal Techniques

USEPA BAT BAT's are not assigned to secondary contaminants.

Alternative Methods of Treatment Generally, there are three processes for reducing alkalinity: nanofiltration, lime softening, Cl⁻ anion exchange (dealkalization), and weak acid cation exchange (dealkalization).

- **Nanofiltration** NF uses a semipermeable membrane, and the application of pressure to a concentrated solution which causes water, but not suspended or divalent ions, to pass through the

membrane. *Benefits*: produces high degree and consistent alkalinity removal, along with high quality water. *Limitations*: cost; pretreatment/feed pump requirements; concentrate disposal.

- **Lime Softening** Lime softening to reduce alkalinity results in a partial reduction of water hardness, and uses controlled amounts of Ca(OH)_2 in sufficient quantity to raise the pH to about 10 to precipitate CO_3^{2-} hardness, after which the precipitated alkalinity is filtered out. The precipitated alkalinity is then removed as a sludge. *Benefits*: lower capital costs; proven and reliable. *Limitations*: operator care required with chemical usage; sludge disposal
- **Ion Exchange** Anion IX to reduce alkalinity uses charged anion resin to exchange acceptable ions from the resin for the undesirable alkalinity in the water. *Benefits*: acid addition, degasification, and repressurization is not required; effective; well developed. *Limitations*: pretreatment lime softening may be required; restocking of regenerate supply; regular regeneration; concentrate disposal.

Cation IX to reduce alkalinity uses charged cation resin to exchange acceptable ions from the resin for hardness ions (Ca and Mg) plus some of the undesirable alkalinity in the water.

Benefits: most suitable for low flows. *Limitations*: requires a hardness-to-alkalinity ratio greater than 1.

References

[1] Benjamin, Mark. Water Chemistry. New York: McGraw-Hill, 2002.

[2] Hemond, Harold, and Elizabeth Fechner-Levy. Chemical Fate and Transport in the Environment, 2nd Edition. San Diego, California: Elsevier Science, 2000.

Contact Information

This Fact Sheet was produced by the TSC's Water Treatment Engineering Team. Address any questions or comments to:

Contact: Bob Jurenka

Email: wtprimer@usbr.gov

Phone: (303) 445-2254

Web: <http://www.usbr.gov/pmts/water/publications/primer.html>

Revision Date: 09/30/09